Jet-Producing Minifilament Eruptions as Keys to Understanding CME-Producing Large-Scale Filament Eruptions

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CMEs Originate from Solar Eruptions

Many large-scale eruptions include eruption of a filament

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Quiet Sun Filament Eruption

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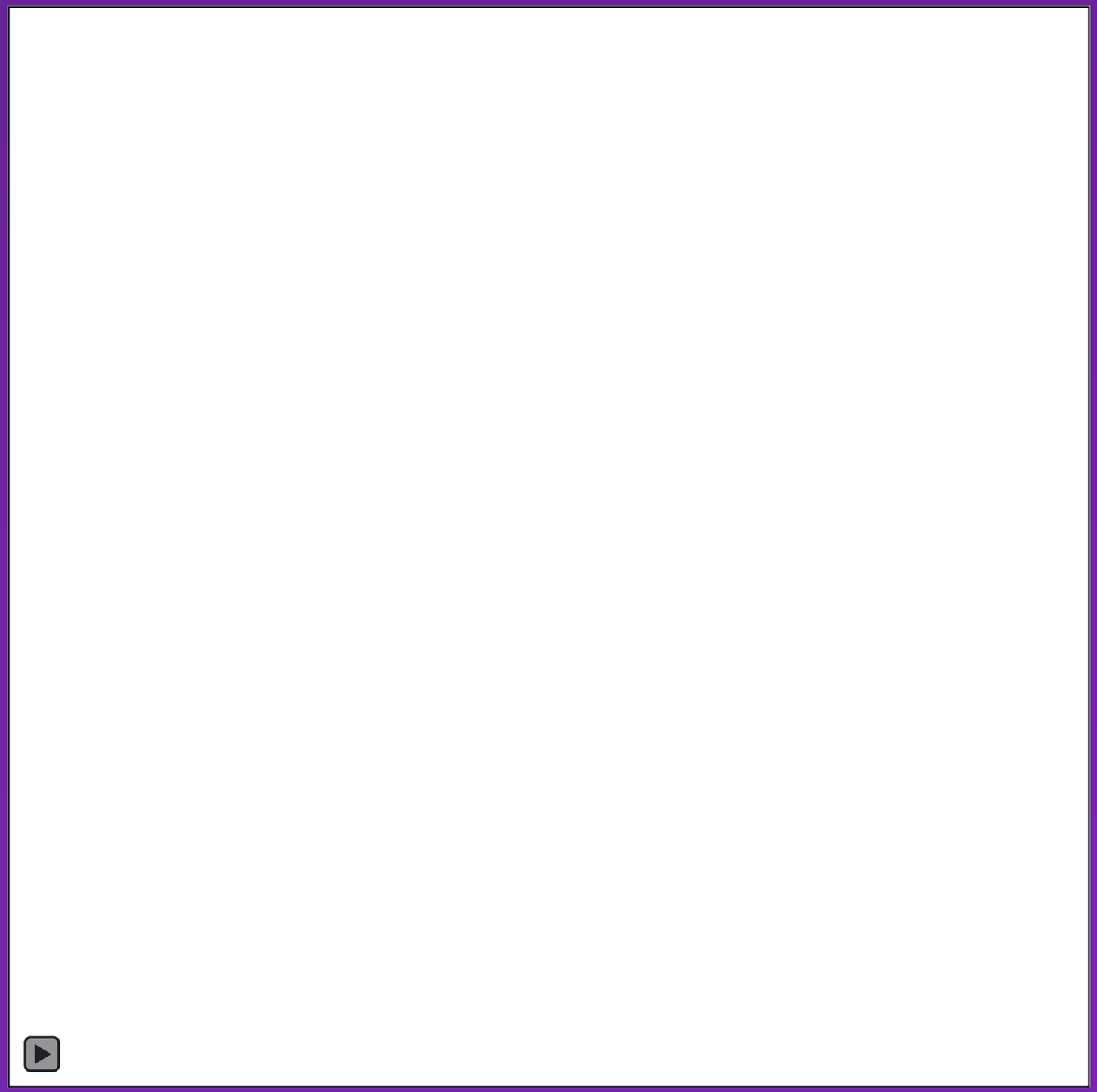

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We want to know: What Causes Large-CME-Producing Filament Eruptions?

In this talk:

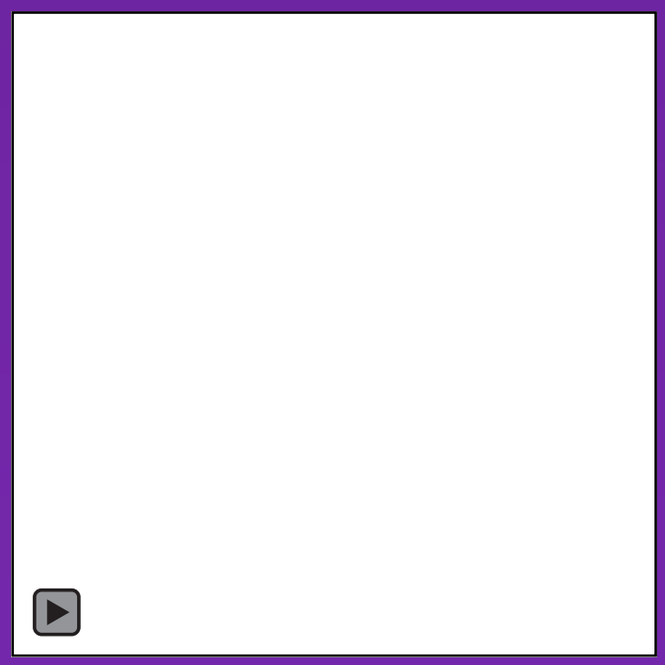
- We will *not* answer this question!
- (Actually, we will not even address it directly)

- We will show that coronal jets result from small-scale filament eruptions.
- These small-scale filament eruptions look like their large-scale counterparts.
- We are learning about the cause of the small-scale eruptions, which might teach us about the large-scale eruptions.

Introduction to Coronal Jets

- Coronal jets are well seen in X-rays and in EUV (e.g., Shibata et al. 1992, Shimojo et al. 1994, Cirtain et al. 2007, Nisticò et al. 2009, Raouafi et al. 2016).
- Often have a “jet bright point’’ on one side of the jet’s base.
- Seen in coronal holes, quiet Sun, and active regions.
- AR jets are similar in appearance to non-AR jets; AR jets are longer and more energetic.

Cirtain et al. (2007)



Sterling et al. (2017)

Coronal Hole Jets: “Minifilament eruptions”

XRT

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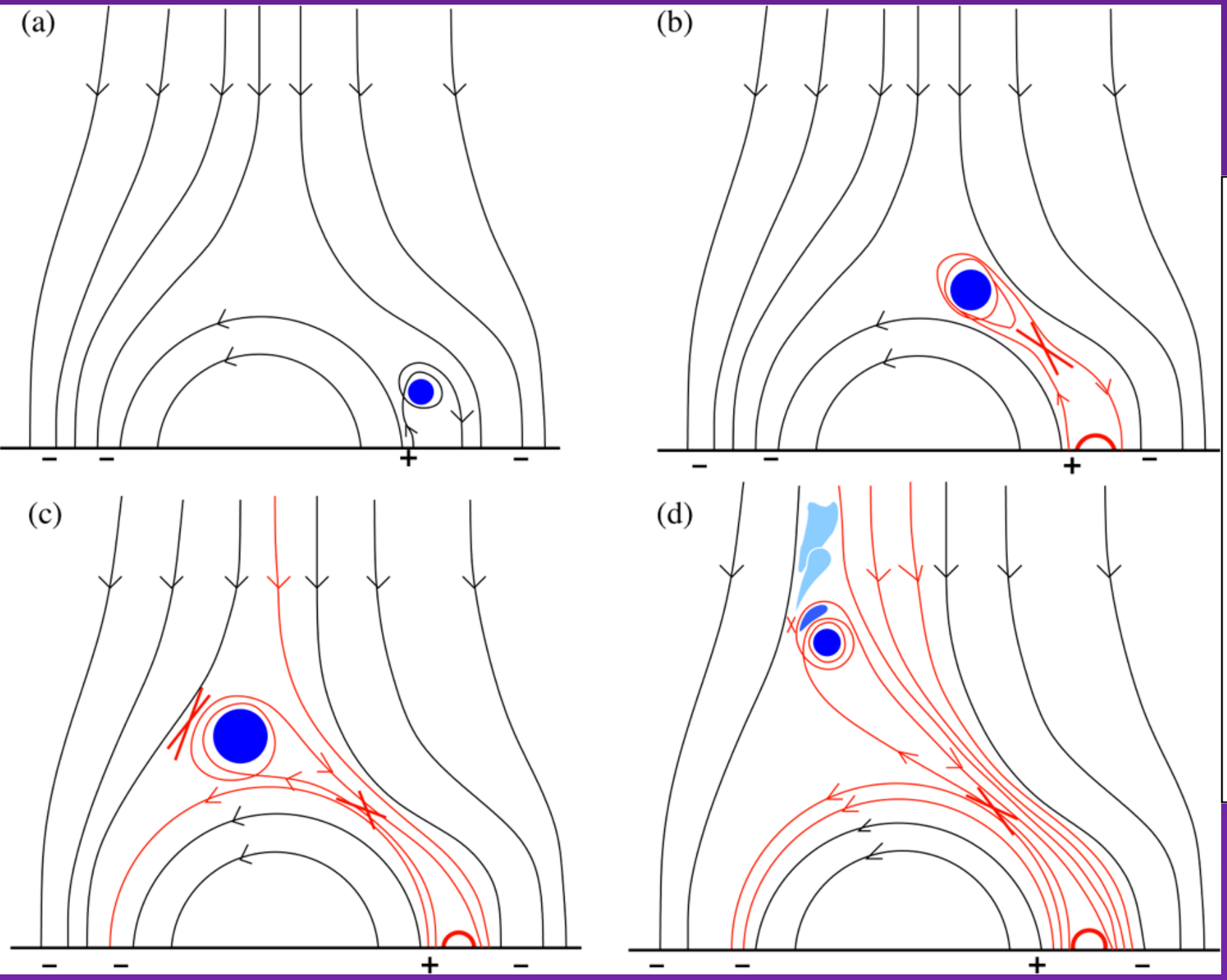
Sterling et al. (Nature, 2015): 20 Polar CH jets.

“Normal” Filament Eruption (TRACE)

A. Sterling, Feb 2016



Sterling et al. (2015, 2016, 2017): “minifilament” eruptions.

Recently modeled by Wyper, Antiochos, & Devore (Nature, 2017)

Quiet Sun Jets - How We Think They Work:

Answer: The same as polar coronal hole jets—minifilament eruptions!

(Panesar et al. 2016, ApJL; 10 quiet Sun jets)

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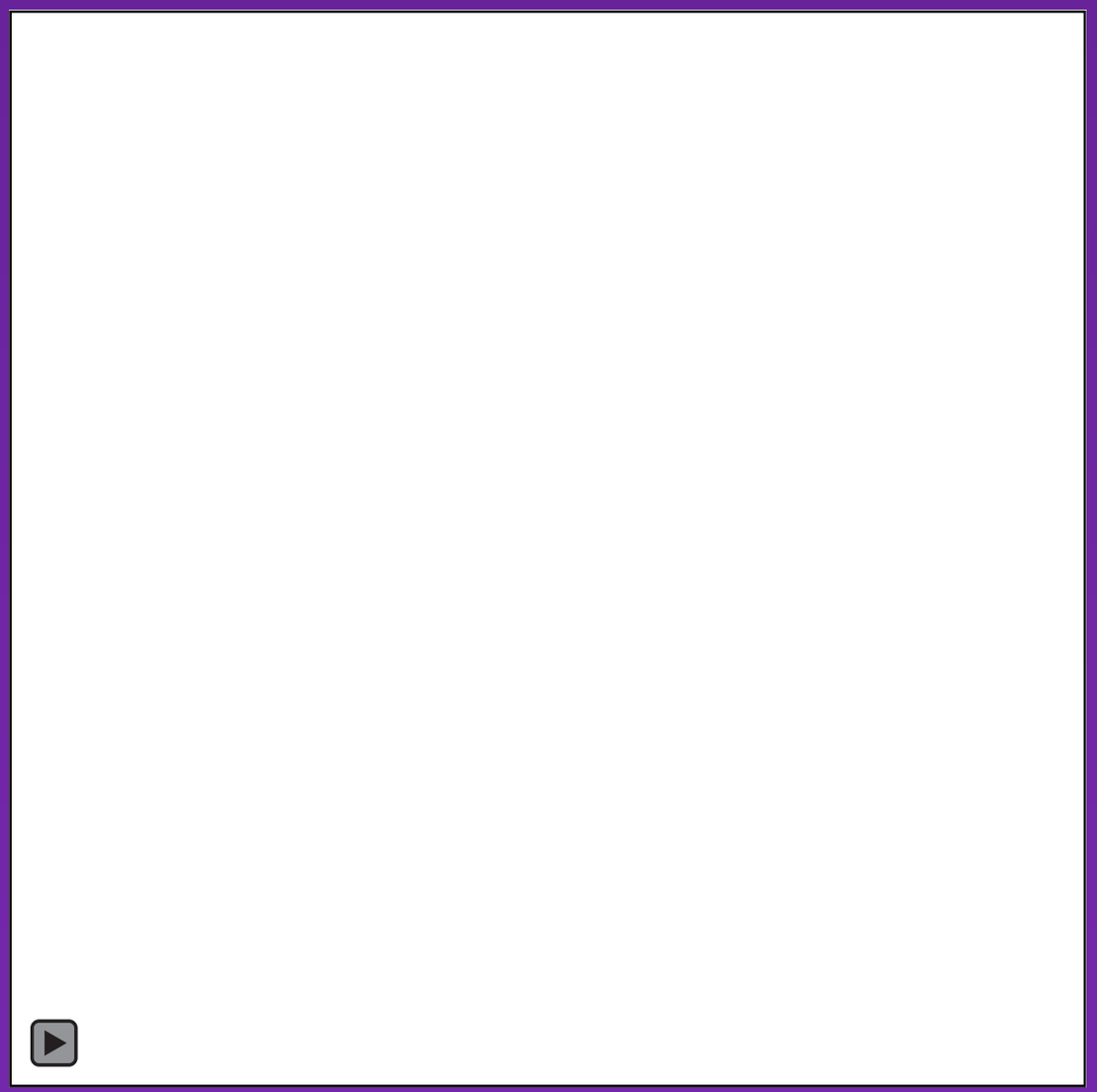
What We Know About Jets:

- Appear in coronal holes (CH), quiet Sun (QS), and ARs.
- Have spires, and brightening at their base.
- Jets in CHs and QS consistently observed to result from minifilament eruptions.
- (For ARs jets, minifilaments frequently not as obvious, but basically consistent with other jets; Sterling et al. 2016, 2017.)

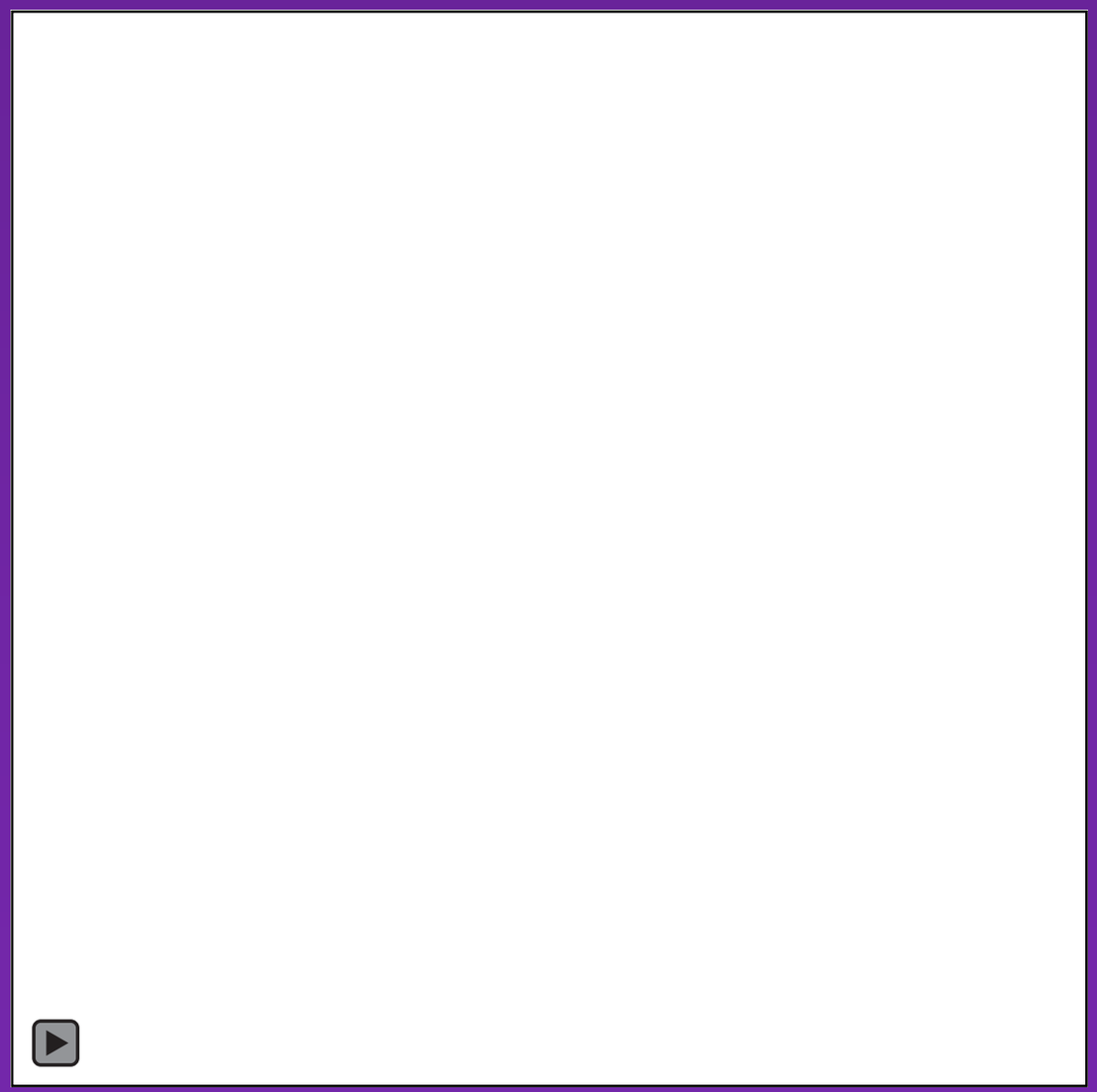
What triggers jet-producing minifilament eruptions?

AR Jet Examples

- 14 Jan 2015 (NOAA AR 12259).
- AIA, HMI, Hinode, IRIS
- Sterling et al. (2017)



Hinode/XRT



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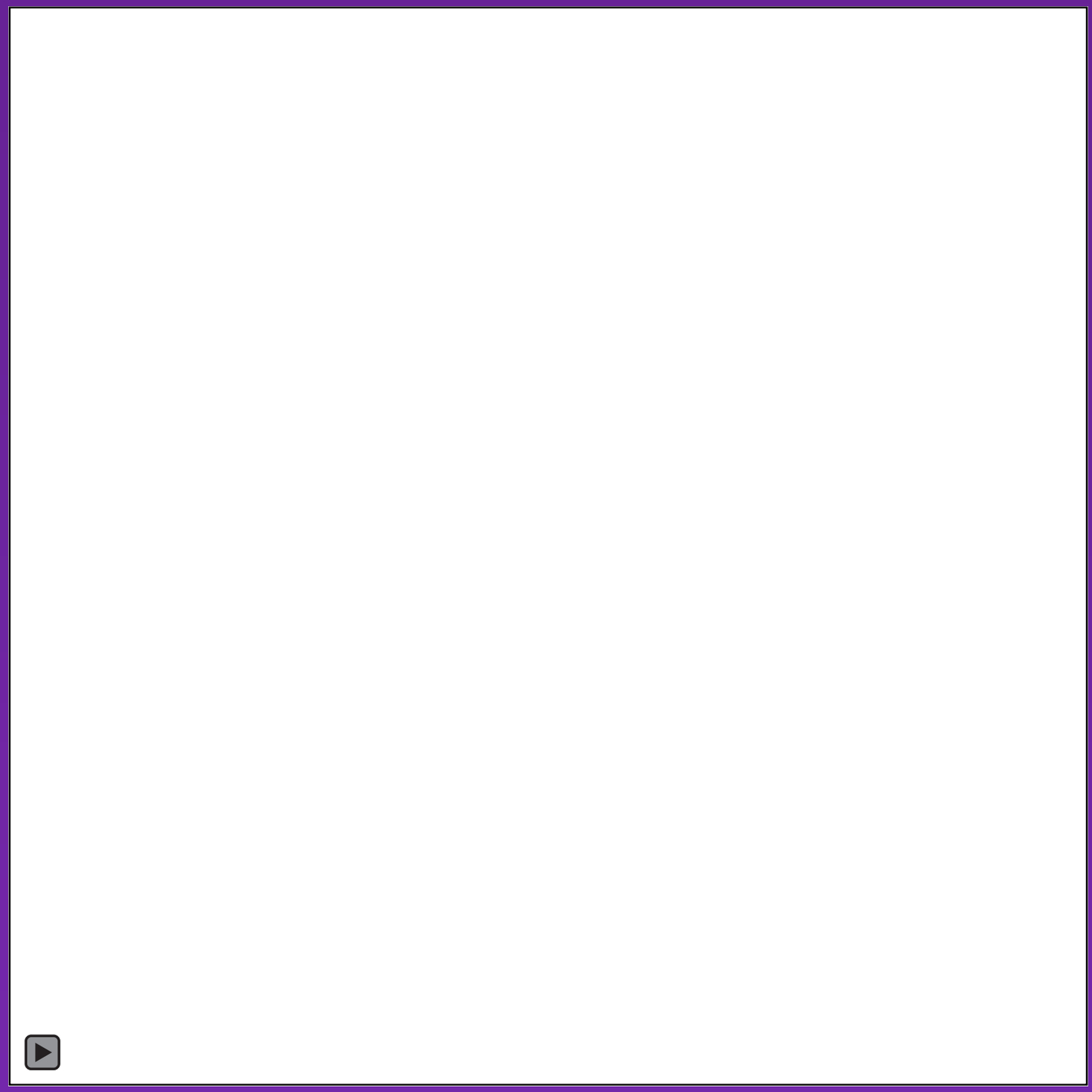
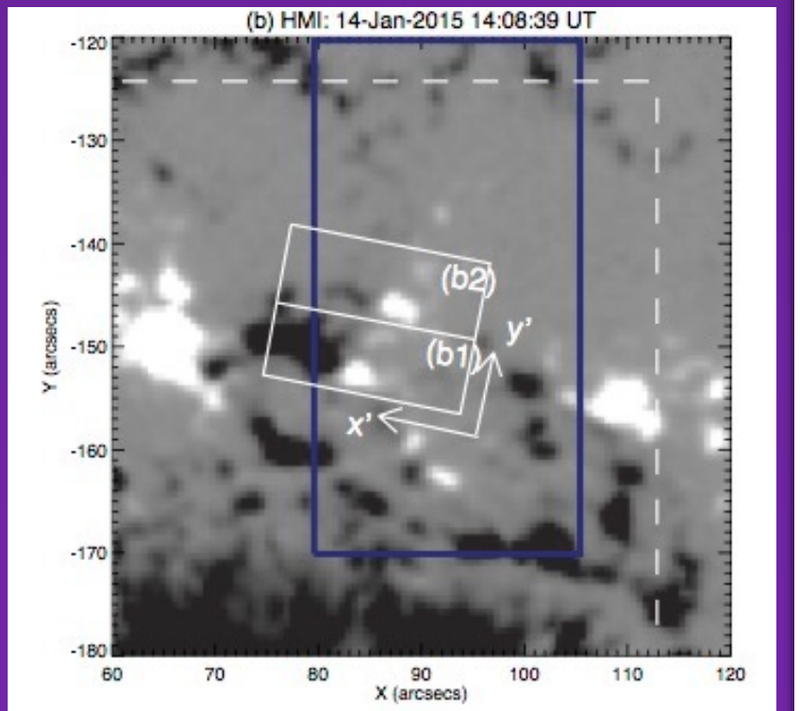
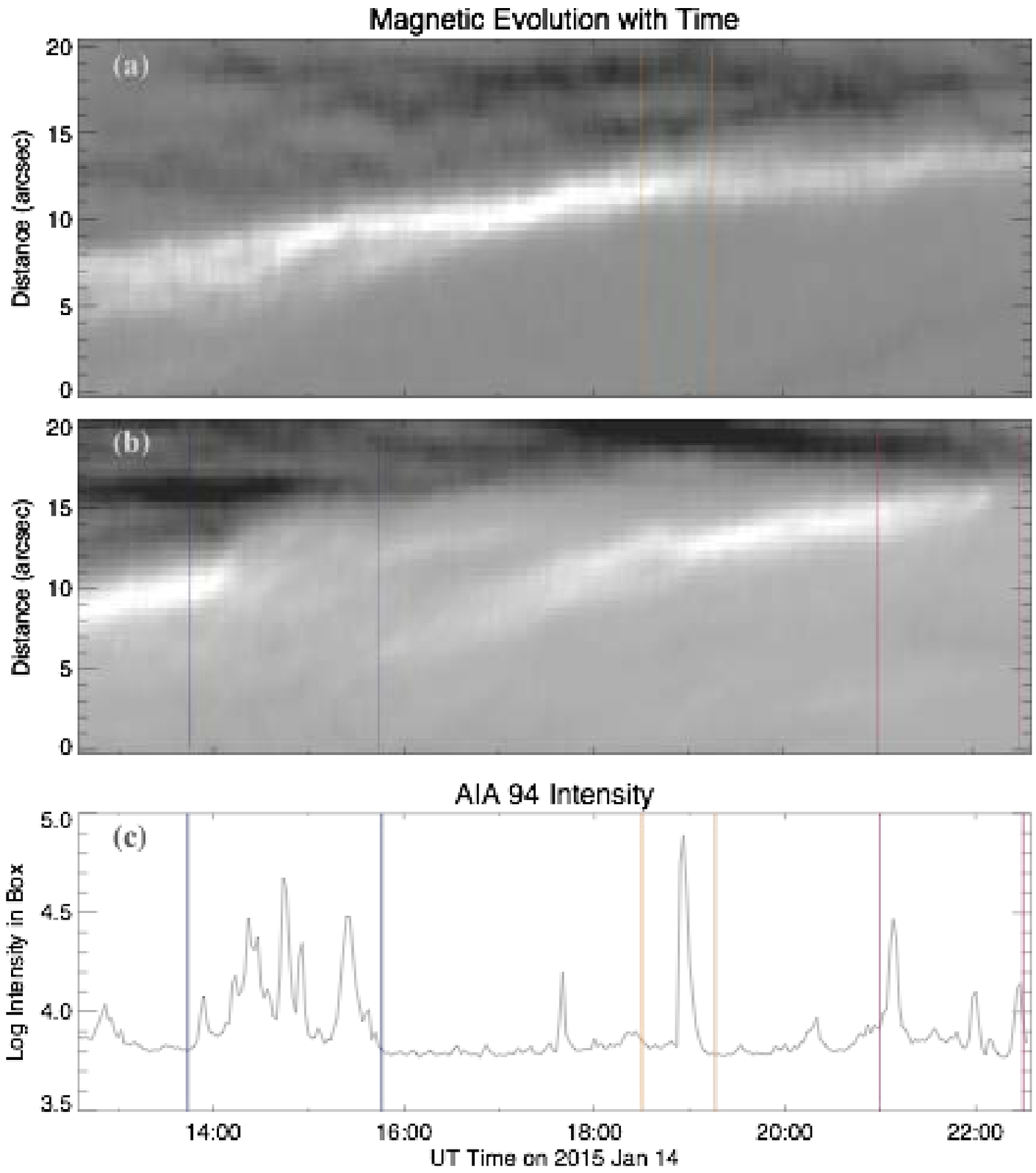
HMI of jetting region



Jets occur at *flux cancelation* locations!

AR jets (Sterling et al. 2017)





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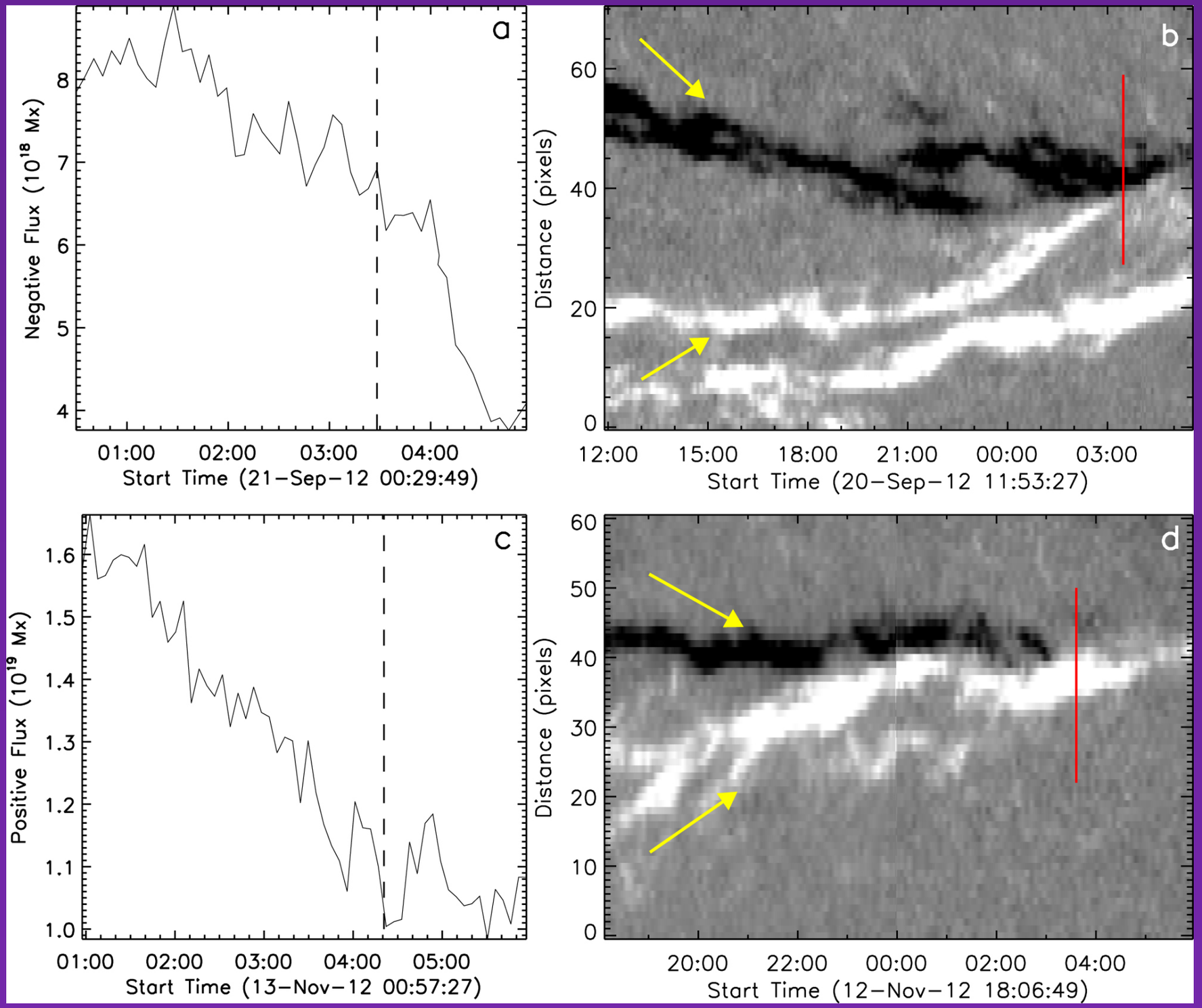
Same for QS jets: Occur at cancelation sites.



Panesar, Sterling, & Moore (2016) — 10 jets.

Summary and Conclusions

- Many Space Weather effects result from CMEs.
- “Large” CMEs result from “large-scale” eruptions, often filament eruptions.
- Coronal jets are small-scale eruptions of “minifilaments.”
- Jets frequently (if not always) result from flux cancelation. (Cf. Young & Muglach 2014, Mulay et al. 2016, many others....)

- By studying minifilaments, we likely can learn about larger-scale eruptions.
- Advantages are: more compact (~50”; great for limited FOV instruments - e.g., DKIST, NGSPM); faster evolution (hours for filament development, instead of many days).

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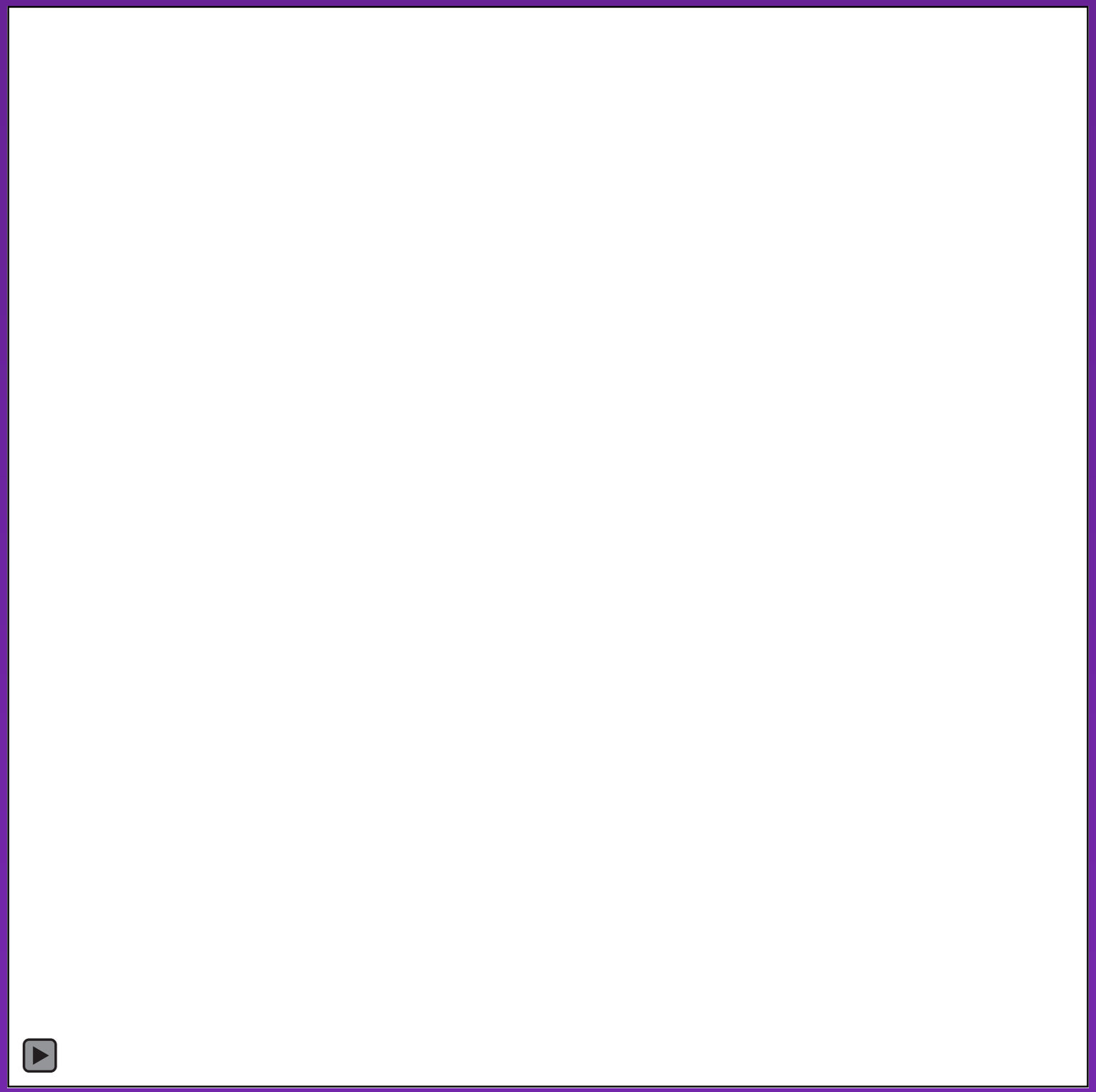

Sterling et al. (2016, ApJ)

Sterling et al. (2016, ApJ)

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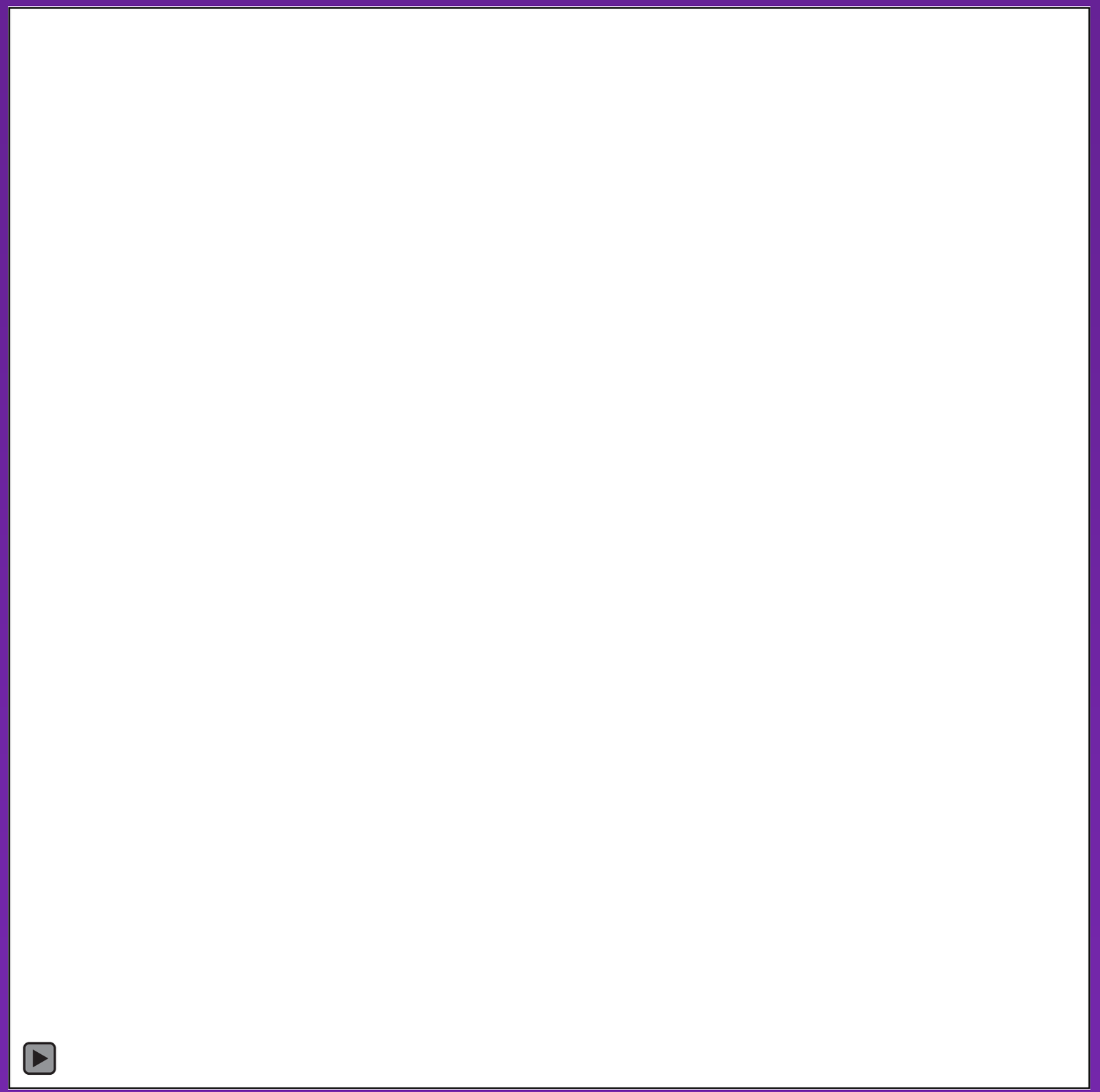

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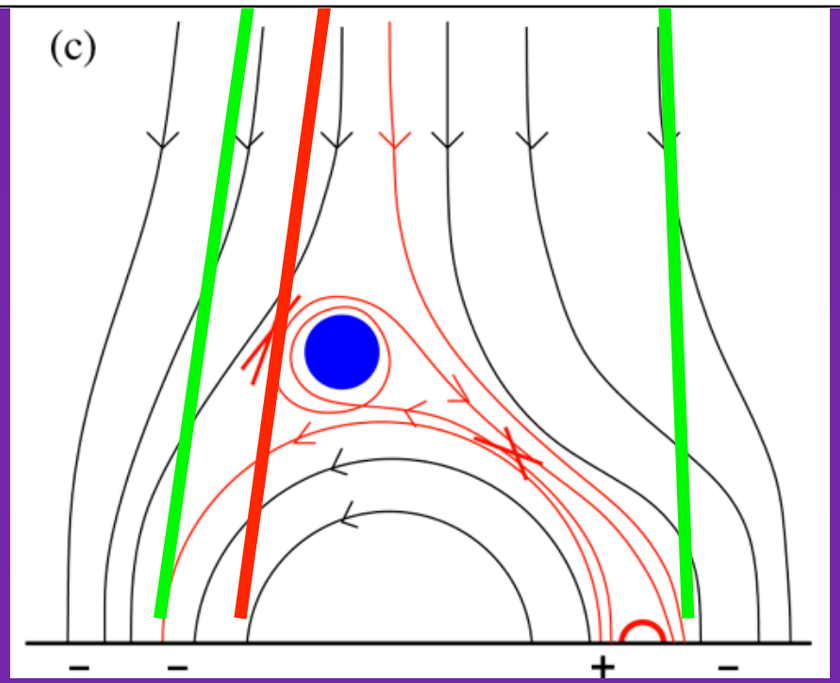

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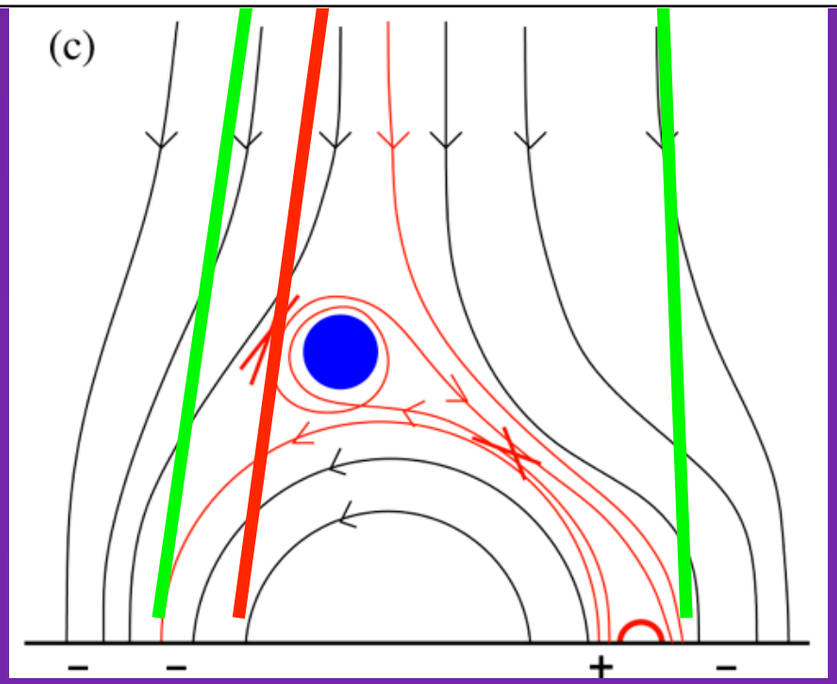

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Flux Cancelation Rates:

Preliminary values (Panesar et al. 2016; Sterling et al. 2017):

- For QS jets (~10 events): ~1.5 x 10^{18} Mx/hr
- For AR jets (~7 events): ~1.5 x 10^{19} Mx/hr